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Which arthroplasty option is superior in hip off-set reconstruction?

Serhat Akçaalan[1], Mehmet Can Kengil[1], Ceyhun Çağlar[1], Mahmut Uğurlu[2]

[1]Department of Orthopedics and Traumatology, Ankara Bilkent City Hospital, Ankara, Turkiye

[2]Department of Orthopedics and Traumatology, Faculty of Medicine, Ankara Yıldırım Beyazıt University, Ankara, Turkiye

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ABSTRACT

Aims: Femoroacetabular offset (hip off-set) plays a very important role in hip joint stability. In this study, it was aimed to determine whether the three different surgical procedures used in total hip arthroplasty (THA) applications have any superiority over each other in terms of femoroacetabular offset restoration.

Methods: This study included 220 patients of 249 hips who underwent THA procedures performed by the senior author. These patients were divided into three groups. Group 1 operated with conventional femoral stems, group 2 operated with short femoral stem and group 3 operated with metal-on-metal hip resurfacing. Femoral off-set, acetabular off-set and hip off-set were measured individually by using pre-operative x-Ray and immediate post-operative x-Ray of all patients.

Results: There were 70 hips in group 1, 84 hips in group 2 and 95 hips in group 3. The measurement results of the short-stem THA group were significantly higher than those of the other groups. Groups pre-operative/post-operative femoral offset; for group 1 32.7±7.5/37.7±8.5 mm, for group 2 35.7±9.7/37.0±8.4 mm and for group 3 36.8±8.9/41.8±8.4 mm. Groups pre-operative/post-operative total offset; for group 1 123.8±9.5/120.7±10.5 mm, for group 2 127.3±17.1/122.9±16.6 mm and for group 3 130.3±14.3/129.7±10.3 mm. When the differences between groups in the changes in the pre-op and post-op offset values were examined, it was found that there were only differences between the femoral measurement results and that the increase of the offset values in group 2 was statistically significantly smaller than that of the other groups.

Conclusion: Short femoral stem THA or hip resurfacing arthroplasty is a better option for femoral offset reconstruction.

Keywords: Hip offset, femoroacetabular offset, short femoral stem, hip resurfacing, conventional femoral stem

INTRODUCTION

Hip osteoarthritis is one of the most common diseases worldwide.[1] It is caused by the cartilage of the hip joint being damaged, which may lead to pain and limitation of movement. Total hip arthroplasty (THA) can change the joint surface, reduce pain, and restore joint function.[2] THA is a successful surgical procedure that improves patients' quality of life and offers satisfactory long-term survival rates.[3,4] The increase in the world's population and life expectancy will lead to an increase in the number of patients undergoing THA and the expectations from this surgical procedure.[5] Despite innovations in both surgical techniques and implant technology over time, the revision burden of the procedure has remained roughly the same.[6] Aseptic loosening, wear, and dislocation are among the most common reasons for revision THA surgery.[7]

Femoroacetabular offset consists of the two components of femoral offset and acetabular offset. Femoral offset is the horizontal distance between the center of rotation of the femoral head and the femoral shaft, while acetabular offset is the horizontal distance between the midline of the pelvis and the center of rotation of the femoral head.[8] In the past, femoroacetabular offset reconstruction was ignored in THA surgery, but recent studies have shown that femoroacetabular offset plays a very important role in hip joint stability.[9] Failure to reconstruct the femoroacetabular offset in accordance with the natural hip structure may restrict the range of motion of the hip and increases the risk of dislocation.[9] In addition to these problems, inadequate offset reconstruction may cause gait disorders due to problems in the gluteal muscle group.[10]

Advances in materials engineering have led to improvements in osteointegration and the use of cementless THA is increasing.[11] Short stems, conventional stems, and hip resurfacing are frequently used in cementless THA applications. Surgeons have high experience with conventional femoral stems due

Corresponding Author: Serhat Akçaalan, akcaalanserhat@gmail.com

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to their good long-term results.[12] However, conventional stems have limited femoracetabular offset reconstruction capability because their design limits placement options.[12] Short-stem THA procedures are becoming more common day by day.[13] Short-stem arthroplasty procedures are reported to reconstruct the hip anatomy better than conventional-stem arthroplasty procedures.[14] And short femoral stems also ensure preservation of bone stock.[12] Another alternative to hip arthroplasty options is hip resurfacing arthroplasty, which is a particularly useful surgical procedure for young and active individuals.[15] The advantages of hip resurfacing arthroplasty over other methods are lower dislocation rate, better postoperative range of motion, and a gait pattern that is closer to normal.[16]

The authors believe that short femoral stems reconstruct the femoroacetabular offset better in light of the data in the literature, so this study aimed to compare the ability of 3 different hip arthroplasty options to reconstruct the femoroacetabular offset and to contribute to the literature for patient-specific implant selection.

METHODS

This study was approved by the Ankara Yıldırım Beyazıt University Health Sciences Ethics Committee (Date: 19.12.2022, Decision No: EK-No. 1239/2019). Due to the retrospective design of the study and the fact that it evaluated pre-existing medical records, informed consent was not required. All procedures performed in the study involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards.

This study included 310 patients who underwent THA procedures performed by the senior author (MU) between 2010 and 2017. These patients were divided into three groups. Patients who underwent hip resurfacing arthroplasty were included in group 1, those who underwent conventional-stem THA were included in group 2, and those who underwent short-stem THA were included in group 3. The Birmingham Hip Resurfacing System® (BHR, Smith & Nephew, London, United Kingdom) was used for all patients who underwent hip resurfacing, the Optimys TM® (Mathys, Bettlach, Switzerland) was used for all patients who underwent short-stem THA, and the Stryker Accolade® II (Stryker, Mahwah, NJ, USA) was used for all patients who underwent conventional-stem THA. All hip arthroplasties were performed using a posterolateral approach. The same reamerization method was used for the acetabular component in all patients. The inclusion criteria of the study consisted of the diagnoses of primary osteoarthritis and hip osteonecrosis. The radiographs were randomly chosen from two ongoing cohorts. The exclusion criteria consisted of previous hip surgery, previous trauma to the hip region, hip dysplasia, coxa vara, coxa valga, protrusio acetabuli, atients with BMI >30, those with diseases that may affect hip offset such as Perthes disease, and those undergoing total hip arthroplasty other than a posterolateral approach. According to these inclusion and exclusion criteria, 249 hips of 220 patients were included in the study. Radiographic measurements were performed via pelvic radiographs taken preoperatively and on the first postoperative day. These pre-op and post-op anteroposterior pelvic radiographs were obtained with the patient in the supine position with the lower extremity in 15° internal rotation and the patella in the frontal plane. Suboptimal pelvic AP x-Rays that did not meet the following criteria in pre-operative and post-operative x-Rays were excluded from the study:

- Obturator foramina and acetabular teardrops appear symmetrical and midsacral line aligns with the pubic symphysis
- Greater trochanters of the proximal femur are in profile and the lesser trochanters are partially superimposed over the femoral neck
- Sacrococcygeal joint 1-3 cm superior to the upper surface of the pubic symphysis

The patients were evaluated based on these anteroposterior pelvic radiographs taken preoperatively and on the first postoperative day. Femoral offset was calculated as the horizontal distance between the center of the femoral head rotation and the femoral shaft, and acetabular offset was calculated as the horizontal distance between the center of femoral head rotation and the midline of the pelvis. The sum of these 2 numerical values was recorded as femoroacetabular offset. These measurements were made based on the preoperative and postoperative radiographs for each patient. These measurement techniques are shown in **Figure 1**. The obtained measurements were individually recorded. Measurements were performed by two different orthopedists who were not part of the surgical team and were blinded to each other's measurements. The mean values of these two different measurements were used for statistical analysis.

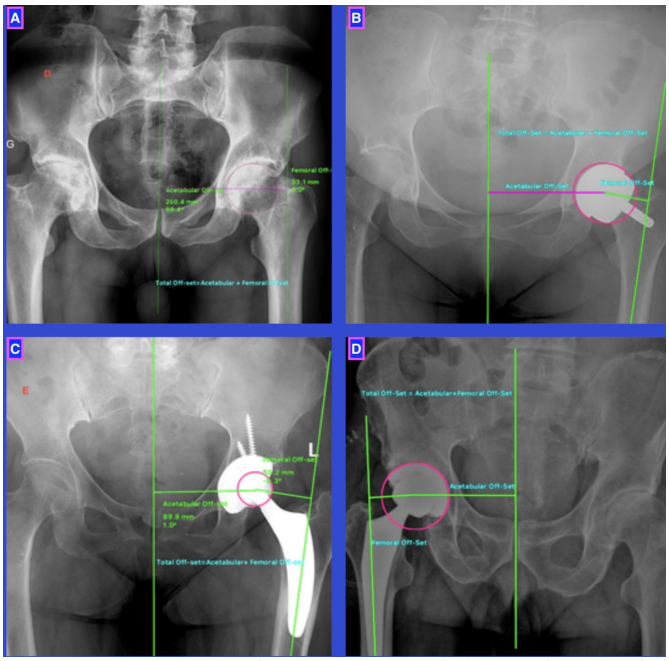

Figure 1. Demonstration of pre-operative acetabular and femoral offset measurement technique (A). Demonstration of post-operative acetabular and femoral offset measurement technique for hip resurfacing group (B). Demonstration of post-operative acetabular and femoral offset measurement technique for short femoral stem group (C). Demonstration of post-operative acetabular and femoral offset measurement technique for conventional femoral stem group (D)

Statistical Analysis

The data analysis was performed using the statistical package SPSS software (Version 25.0, SPSS Inc., Chicago, IL, USA). If continuous variables were normal, they were described as the mean±standard deviation [p>0.05 in Kolmogorov-Smirnov

test or Shapira-Wilk (n<30)], and if the continuous variables were not normal, they were described as the median. Comparisons between groups were applied using student T test or one way ANOVA for normally distributed data. The categorical variables between the groups were analyzed by using the chi-square test or Fisher Exc test. Pre-post measures data were analysed paired T test and repeated measure analysis. Values of p<0.05 were considered statistically.

RESULTS

In total, 249 hips of 220 patients were included in this study. Of these patients, 70 underwent hip resurfacing arthroplasty (group 1), 84 underwent conventional-stem THA (group 2), and 95 underwent short-stem THA (group 3).

The pre-op and post-op acetabular, femoral, and total offset values of all three groups are presented in Table.

When the offset measurement results of the groups were compared, it was found that there were statistically significant differences between the results of the groups except for the pre-op acetabular measurement results. As a result of post hoc analysis, it was determined that the statistical difference between the groups was due to the short-stem THA group (group 3). The measurement results of the short-stem THA group were significantly higher than those of the other groups.

When the changes of the results within the groups over time were analyzed, it was found that there were statistically significant differences between the pre-op and post-op results of group 1. There were statistically significant differences between all pre-op and post-op results of group 2 except for femoral offset measurements. There were also statistically significant differences between all pre-op and post-op results of group 3 except for total offset measurements.

When the differences between groups in the changes in the pre-op and post-op offset values were examined,it was found that there were only differences between the femoral measurement results and that the increase of the offset values in group 2 was statistically significantly smaller than that of the other groups.

Pre-op and post-op acetabular offset changes, femoral offset changes, and total offset changes of all three groups are shown in Figure 2, Figure 3, and Figure 4, respectively.

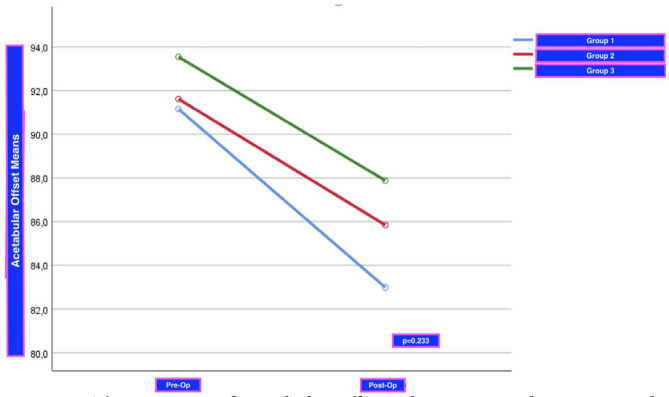

Figure 2. The variation of acetabular offset values measured preoperatively and postoperatively is shown

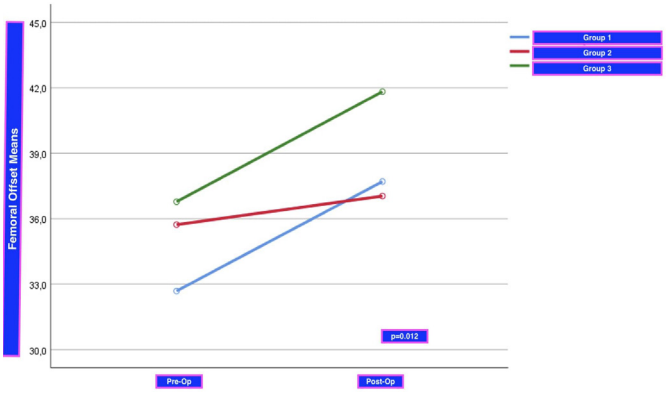

Figure 3. The variation of femoral offset values measured preoperatively and postoperatively is shown

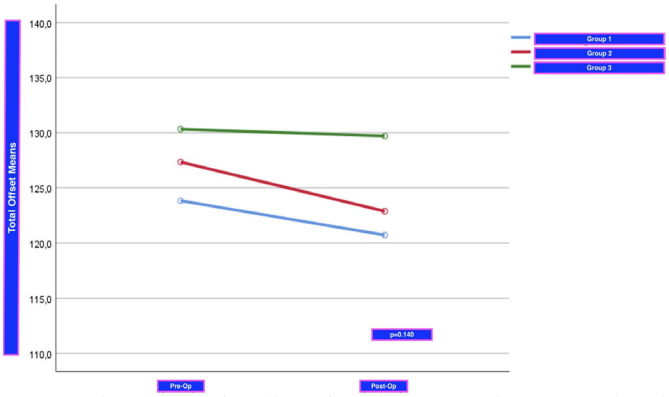

Figure 4. The variation of total hip offset values measured preoperatively and postoperatively is shown

Table. Preoperative and postoperative acetabular, femoral and femoroacetabular offset values of the groups and data on their statistical analyses

	Group 1, hip resurfacing arthroplasty (n=70)		Group 2, conventional-stem THA (n=84)		Group 3, short-stem THA (n=95)		p values
	Mean±SD	Min-max	Mean±SD	Min-max	Mean±SD	Min-max	p
Pre-op acetabular offset	91.2±7.1	74-109	91.6±13.3	59-133	93.5±11.2	65-123	0.324
Post-op acetabular offset	82.9±7.0	64-95	85.8±11.5	55-135	87.9±8.3	65-114	0.004
p*	0.0001		0.0001		0.0001		
Pre-op femoral offset	32.7±7.5	17-50	35.7±9.7	8.7-63	36.8±8.9	21-60	0.012
Post-op femoral offset	37.7±8.5	17-58	37.0±8.4	18-56	41.8±8.4	25-65	0.0001
p*	0.0001		0.211		0.0001		
Pre-op total offset	123.8±9.5	104-150	127.3±17.1	93-176	130.3±14.3	88-158	0.016
Post-op total offset	120.7±10.5	97-150	122.9±16.6	81-185	129.7±10.3	91-166	0.0001
p*	0.008		0.007		0.664		

All measurements in the table are in millimeters. p: One-way analysis of variance, p*: Dependent group T test, THA: Total hip arthroplasty, SD: Standard deviation, Min: Minimum, Max: Maximum

DISCUSSION

In THA, it is very important to restore the hip according to its natural anatomy since this has an impact on important parameters such as the risk of dislocation, range of motion, and wear.[17] Hip resurfacing arthroplasty, conventional-stem THA, and short-stem THA are common hip surgery procedures. The most important finding of this study is that short femoral stems are radiologically superior to conventional femoral stems and hip resurfacing in femoro-acetabular offset reconstruction.

The studies in the literature on acetabular offset reconstruction are limited in number.[18,19] In the acetabular preparation phase of THA, the acetabulum is resurfaced until the true acetabular floor is reached. Resurfacing of the acetabulum to the true acetabular floor reduces the lever arm of body weight during the monopedal stance, which reduces the compound force on the femoral head and thus improves the survival rate of THA.[20,21] For these reasons, all THA patients in this study underwent medialization for acetabular cup preparation. Similar to other studies, it was seen that this procedure reduced the acetabular offset in all groups in the postoperative period.[20,22] It is also known that the acetabular offset depends on the acetabular configuration, the surgeon's experience, and the technique used rather than the design of the cup.[23]

Different stem designs have been developed and used over the years to ensure that the implant maintains optimal bone integrity, exhibits adequate tribological properties, provides minimal bone resorption, and preserves hip geometry.[24] Short femoral stems have satisfactory short- and medium-term clinical outcomes.[25] Although conventional femoral stems also have satisfactory survival times, they are less successful than short stems, especially in femoral offset reconstruction.[14,26] Waard et al.[12] also compared short femoral stems with conventional stems using a templating program on femoroacetabular offset restoration in total hip arthroplasty and found that short femoral stems are potentially better at restoring femoroacetabular offset than conventional stems if the preoperative offset is ≥80.0 mm. There are no studies in the literature on the ability of hip resurfacing arthroplasty to reconstruct the femoral offset. In our study, the postoperative femoral offset values of both the resurfacing arthroplasty group and the short-stem THA group were statistically significantly higher than the preoperative values. However, no statistical difference was found between the preoperative and postoperative femoral offset values of the conventional-stem THA group. It was also found that the short-stem THA group had statistically significantly higher femoral offset increase compared to the other groups. In their study evaluating the results of procedures using two different short stems and conventional stems, Maurer-Ertl et al.[27] showed that hip geometry reconstruction could be achieved more easily with short stems. Increasing the femoral offset ensures less joint reaction force, slows polyethylene wear, reduces the risk of dislocation, and allows the patient to have a healthier gait pattern.[9,10,28] In their study, Sneijders et al.[14] emphasized that femoral offset reconstruction with short femoral stems was more successful than femoral offset reconstruction with conventional stems. Many recent studies in the literature have shown that short-stem THA can be used to adequately reconstruct hip geometry.[29-33] All of these studies emphasize that increasing the femoral offset will have positive effects on hip geometry reconstruction. However, there is no clear consensus on how much the femoral offset should be increased to achieve the best results. Although not identifying the extent to which the femoral offset should be increased, Bullen et al.[34] showed in their study that a decrease of more than 20 mm in femoral offset during THA will have a serious impact on clinical scores, necessitating the establishment of a cut-off value. The current study has shown that hip resurfacing arthroplasty has effects similar to those of short-stem THA, especially in reconstructing the femoral offset.

In order to compensate for the decrease in acetabular offset due to acetabular medialization, it is necessary to increase the femoral offset. Otherwise, a decrease in total offset will occur, causing negative effects on the hip joint. In the present study, it was observed that total offset decreased in all groups postoperatively. This shows that the femoral offsets of the patients were not increased enough to tolerate a decrease in acetabular offset. It was also observed that the total offset values of none of the patients were below the cut-off value reported by Bullen et al.[34] However, in another study, it was reported that a decrease of 5 mm in total offset was sufficient for the associated clinical adverse effects to occur.[17] Accordingly, digital templating should be used in preoperative preparations and the acetabular, femoral, and total offsets of patients should be calculated. Patient-specific implants should be selected according to the results of these calculations.

The importance of anatomical reconstruction of the hip offset has been emphasized quite clearly in the literature. Kelly et al.[35] showed that in addition to the negative biomechanical effects, decreased hip offset also has a negative effect on patient reported outcomes. Digital templating systems can be used successfully to minimize the biomechanical and clinical effects of not performing anatomical offset reconstruction.[36] There is information in the literature that BMI negatively affects offset reconstruction, so including demographic data in the analysis will allow for better evaluation of the data.[37]

Limitations

This study has some limitations. First of all, its retrospective design naturally creates a limitation. Apart from this, the demographic characteristics of the patients (age, height, weight, BMI, etc.) were not included in the study. The lack of reliability and validity studies for radiological measurements can be considered a limitation. However, the authors did not conduct this examination because this measurement method, which has been previously studied for reliability and validity, is accepted in the literature. Conducting reliability and validity analysis related to the measurements may help overcome the limitations in future studies. Another limitation of the study is that the measurements were made on 2D radiographs without computer support.

CONCLUSION

The current study has shown that the implant and surgical method used, and the experience of the surgeon can all impact the success of hip geometry reconstruction. Increasing the femoral offset in femoral offset reconstruction is both clinically and radiologically important and, in this study, it was easier to achieve this increase with hip resurfacing arthroplasty or short-stem THA. Clinical evaluation of radiological data obtained with larger comparative groups would reveal the advantages and disadvantages of these implant types more clearly.

ETHICAL DECLARATIONS

Ethics Committee Approval

The study was carried out with the permission of Ankara Yıldırım Beyazıt University Health Sciences Ethics Committee (Date: 19.12.2022, Decision No: EK-No. 1239/2019).

Informed Consent

Because the study was designed retrospectively, no written informed consent form was obtained from patients.

Referee Evaluation Process

Externally peer-reviewed.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Financial Disclosure

The authors declared that this study has received no financial support.

Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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